APPENDIX E
STREAM BANK EROSION INVENTORY

In September 2006, in conjunction with a base parameter assessment, field crews inventoried eroding banks to determine the amount of sediment they contribute to the overall sediment load.

Data Collection

The bank erosion inventory recorded the location and characteristics of stream banks with discernable bank erosion on assessed reaches. These data provided the basis for developing a sediment source assessment and load allocation from eroding banks. For tributary streams, this inventory was performed on 1000 foot transects along both banks of the stream coincident with base parameter data collection.

The erosion site assessment includes a description of each eroding bank within each assessment reach, including the following:

- length
- height
- location (mapped)
- unadjusted BEHI rating
- unadjusted BEHI condition
- adjusted BEHI rating
- adjusted BEHI condition
- topbank vegetation type
- topbank vegetation density
- proximal land use
- bank materials

The bank condition evaluation utilized the BEHI method (Rosgen, 2000) and incorporated the following parameters into numerical ratings.

- Bank height/bankfull height ratio
- Root depth/bank height ratio
- Root density percent
- Bank angle
- Surface protection percent

Field crews measured eroding bank lengths with a tape measure along the thalweg of the stream. Bank height was measured using a stadia rod extended from the toe of the eroding bank to the top of the bank. Location is recorded using the continuous stationing method. The Bank Erosion Hazard Index (Rosgen, 2000), which allows the determination of the severity of mapped eroding streambanks, was performed according to procedures laid out in the Quality Assurance Project Plan and Sampling and Analysis Plan.

Data Analysis

Analysis of stream bank erosion inventory data involved five tasks:

- Calculation of erosion rates based on condition and distribution of eroding banks mapped at assessment sites
- Extrapolation of these rates to reaches of 303(d) streams not assessed
- Determination of erosion rates of streams not on the 303(d) List

- Calculation of the total sediment load from bank erosion
- Estimation of the natural and anthropogenic components of the sediment load

Calculation of Erosion Rates

The BEHI bank condition evaluation generated a cumulative rating that provides a qualitative erosion severity assessment (very low to extreme). A literature review provided a range of probable bank retreat rates corresponding to the severity assessment. Retreat rates developed by Zaroban and Sharp (2001) for the Palisades TMDL in Idaho were most applicable (**Table E-1**).

Table E-1. Eroding Bank Retreat Rates Used for the Sediment Source Assessment

Zaroban and Sharp (2001) Condition	Zaroban and Sharp (2001) Bank Retreat Rate (feet/yr)	Lower Blackfoot Eroding Bank Condition Rating	Lower Blackfoot Bank Retreat Rate (feet/yr)
Slight	0.1	Very low	0.10
		Low	0.17
Moderate	0.23	Moderate	0.23
		High	0.31
		Very High	0.39
Severe	0.47	Extreme	0.47

Multiplying eroding bank length times height times retreat rate yielded a yearly volume of sediment from eroding banks. Multiplying these volumes by the density of soils from SSURGO soils data yields a yearly tonnage of sediment from bank erosion for each stream.

Extrapolation of Bank Erosion to Reaches Not Assessed

Calculating the bank erosion rate for each stream on the 303(d) List, required extrapolating erosion rates to reaches not assessed. This required identifying a list of controlling factors on bank erosion, supported by existing data that are simple enough to use for this extrapolation (**Table E-2**). This approach required using one of two processes:

- Identify assessed reaches with similar upstream precipitation, geology, vegetation, and land use as those not assessed and assign the same erosion rate to the un-assessed streams
- If no directly analogous assessed stream exists, average the erosion rate of assessed upstream and downstream reaches

Table E-2. Criteria Used to Extrapolate Bank Erosion Rates to Un-Assessed Reaches

Controlling Factor on Bank Erosion	Effect on Sediment Loads	Available data
Stream Power	Stream power directly influences stress on stream banks and is a function of discharge and slope.	A surrogate for stream power is the amount of average annual precipitation upstream from a given reach.
Geology	Geology and derived soils directly influence erodibility of stream banks	Generalized geologic mapping and NRCS soils mapping data are available for the project area.
Vegetation	Vegetation density and type influence stream bank resilience.	Topbank vegetation type density data was collected during the field assessment at the reach and eroding bank scale
Land Use	Land use can influence vegetation density, which influences bank resilience. Upland vegetation	Land use data was collected during the field assessment at the reach and individual eroding bank scales.

Table E-2. Criteria Used to Extrapolate Bank Erosion Rates to Un-Assessed Reaches

Controlling Factor on Bank Erosion	Effect on Sediment Loads	Available data
	clearing can increase runoff and stream power. Roads can directly contribute sediment loads. Mining can influence bank resilience (e.g. placer tailings), and vegetation.	DEQ data provides stream scale land use information.

Determination of Background Bank Erosion Rates

Streams not on the 303(d) List are also a source of sediment from bank erosion. To estimate this portion of the sediment load, the relationships between upstream precipitation, channel type, geology, woody vegetation density, and land use with measured bank erosion rate were examined. The comparison of upstream precipitation with bank erosion rate has the clearest relationship. **Figure E-1** illustrates this relationship for the Lower Blackfoot Planning Area.

A continuous grid dataset for the study area that represents the upstream average annual precipitation for each cell in the grid was developed to apply the numerical relationship between upstream precipitation and bank erosion rates. Only grid cells that intersect stream channels have values. Multiplying each grid cell by 0.002 yields a bank erosion grid. The bank erosion grid was then summarized for non-303(d) streams.

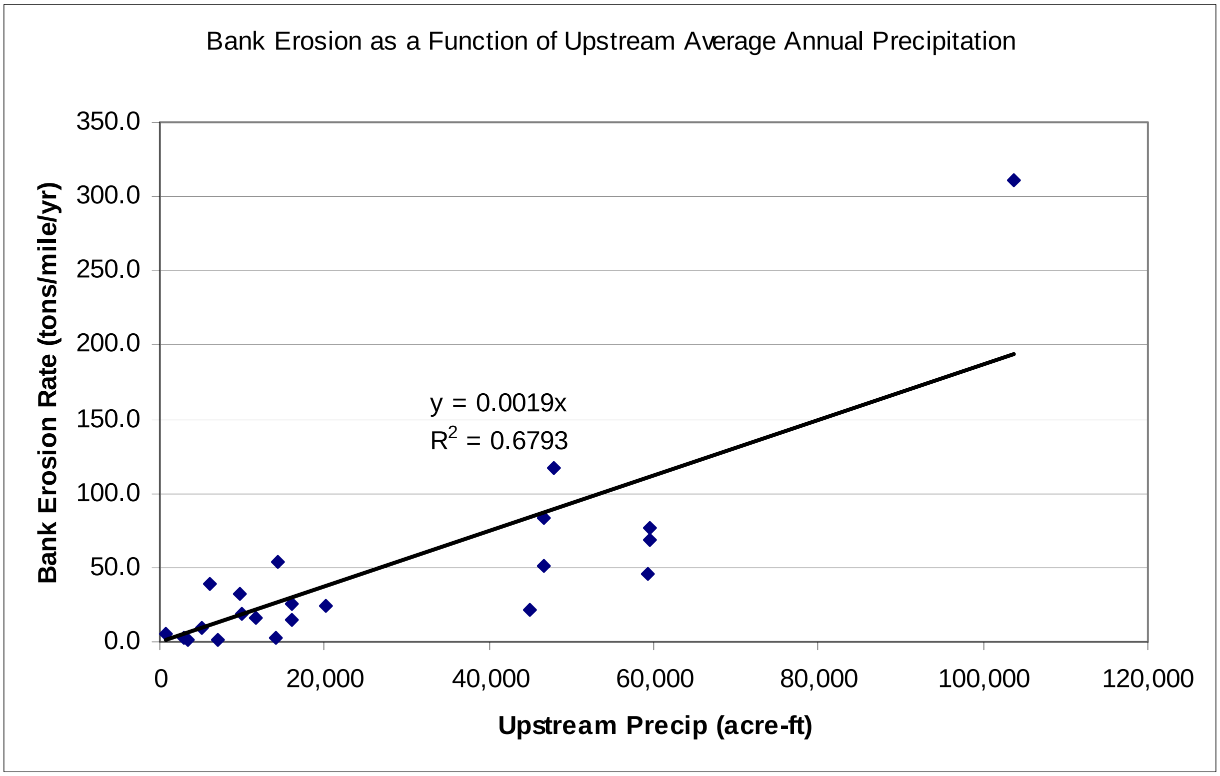

Figure E-1. Scatter Plot of Upstream Precipitation vs. Measured Bank Erosion Rate, Nevada Creek Planning Area

The formula defined in **Figure E-1** is:

Bank Erosion Rate = 0.0019 * (Upstream Precipitation)

This formula was then applied to the grid, along with a unit conversion multiplier, to yield a stream network grid where each cell represents the predicted bank erosion rate of a portion of a stream. Summarizing the grid cell values for the Lower Blackfoot Creek planning area yielded a modeled sediment contribution for the entire watershed. The sediment contribution for non-303(d) List streams is then the modeled sediment contribution minus the measured and extrapolated sediment contribution from 303(d) List streams.

Total Sediment Load from Bank Erosion

The total sediment load from bank erosion is the sum of the three components described above:

- The sediment load from eroding banks measured on 303(d) streams
- The sediment load from eroding banks extrapolated to un-assessed reaches on 303(d) streams
- The background sediment load from eroding banks on non-303(d) List streams.

Table E-3 identifies the loading estimate methods and results for each assessment reach.

Table E-3. Measured and Extrapolated Streambank Erosion Rates by Listed Stream Segment and Assessment Reach.

Stream	Reach	Length (ft)	Assessed Site	Measured Erosion Rate (ft^3/1000ft/yr)	Erosion Rate (tons/mile/yr)	Basis for Extrapolation	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Day Gulch	Day1	3,274			0.5	Modeled Background Rate	0.3	4.7
	Day2	4,028	Day2	13.9	5.7		4.4	
Keno Creek	Keno1	2,357			0.5	Modeled Background Rate	0.2	4.7
	Keno2	6,653			2.1	Similar to Keno3	2.6	
	Keno3	2,057	Keno3	5.0	2.1		0.8	
	Keno4	4,685	Keno4	1.9	0.8		0.7	
Elk Creek, Upper	Elk1	3,389			0.5	Modeled Background Rate	0.3	91.9
	Elk2	9,915			2.1	Similar to Keno3	3.9	
	Elk3	8,972	Elk3	44.9	18.5		31.4	
	Elk4	4,354			18.5	Average of Elk 3 and Elk 5	15.2	
	Elk5	12,618	Elk5	10.5	4.3		10.4	
	Elk6	8,642			18.5	Similar to Elk3	30.3	
Elk Creek, Lower	Elk7	15,887	Elk7	201.5	67.4	Average of 2 assessments	202.7	449.9
			Elk7b	125.4				
	Elk8	4,496	Elk8	283.1	116.6		99.3	
	Elk9	7,241	Elk9	111.1	45.8		62.8	
	Elk10	6,224	Elk10	165.8	72.3	Average of 2 assessments	85.2	
			Elk10b	185.0			0.0	
Belmont Creek	Bel1	10,606			0.5	Modeled Background Rate	1.0	83.0
	Bel2	23,540	Bel2	6.4	2.6		11.7	
	Bel3	16,348			12.1	Average of Bel2 and Bel4	37.6	
	Bel4	7,962	Bel4	52.6	21.7		32.7	
Washoe Creek	Washoe 1	4,579			0.5	Modeled Background Rate	0.4	115.3
	Washoe 2	22,957			18.5	Similar to Elk3	80.4	
	Washoe 3	6,949			18.5	Similar to Elk3	24.3	
	Washoe 4	1,633	Washoe4	79.3	32.7		10.1	

Table E-3. Measured and Extrapolated Streambank Erosion Rates by Listed Stream Segment and Assessment Reach.

Stream	Reach	Length (ft)	Assessed Site	Measured Erosion Rate (ft^3/1000ft/yr)	Erosion Rate (tons/mile/yr)	Basis for Extrapolation	Total Reach Sediment Load (tons/yr)	Total Stream Sediment Load (tons/yr)
Ashby Creek, East	EAshb1	3,778			0.5	Modeled Background Rate	0.4	6.5
	EAshb2	8,331			1.7	Similar to EAshb3	2.7	
	EAshb3	10,814	EAshb3	4.1	1.7		3.4	
Ashby Creek, West	WAshb1	5,946			0.5	Modeled Background Rate	0.6	15.7
	WAshb2	3,540			1.7	Similar to EAshb3	1.1	
	WAshb3	7,903	WAshb3	22.6	9.3		14.0	
Camas Creek	Cam1	5,074			0.5	Modeled Background Rate	0.5	468.0
	Cam2	10,577	Cam2	266.2	109.7		219.7	
	Cam3	4,167			82.0	Average of Cam2 and Cam4	64.8	
	Cam4	9,224	Cam4	132.1	54.4		95.1	
	Cam5	4,971			24.0	Similar to Cam6	22.6	
	Cam6	10,357	Cam6	58.3	24.0		47.1	
	Cam7	4,023			24.0	Similar to Cam6	18.3	
Union Creek	Union1	27,069	Union1	93.2	38.4		196.9	3221.3
	Union2	7,513			18.5	Similar to Washoe3 and Elk3	26.3	
	Union3	7,461			18.5	Similar to Washoe3 and Elk3	26.1	
	Union4	2,576	Union4	40.0	16.5		8.0	
	Union5	7,776	Union5	387.7	159.8		235.3	
	Union6	14,080			54.4	Similar to Cam4	145.1	
	Union7	4,200			24.0	Similar to Cam6	19.1	
	Union8	6,487	Union8	62.5	20.1	Average of 2 assessments	24.7	
	Union8	6,487	Union8b	35.2				
	Union9	4,605			99.5	Estimated bank height and condition from photographs	86.8	
	Union10	25,840			310.7	Similar to Union11	1520.7	
	Union11	15,821	Union11	754.2	310.7		931.1	
	Union12	4,401	Union12	3.4	1.4		1.2	
							TOTALS:	4461.0

ft^3 to tons conversion: ft^3 * 28316.8cm3/ft3 * 2.5g/cm3 * 1lb/453.6g * 1ton/2000lb

Natural vs. Anthropogenic Components of Bank Erosion Sediment

The approach used to estimate the anthropogenic component of bank erosion for eroding banks with a recorded human influence was to estimate a reduced severity of bank erosion without human impacts. A reduced human impact would improve vegetation density on both the topbank and eroding bank surface, as well as improve the root depth and density in the eroding bank. Bank height should be unaffected and bank angle may improve slightly over time.

Estimating of the amount of change in the five BEHI rating parameters likely from passive restoration for a series of representative eroding banks evaluated the potential change in bank condition from removing the human influence. This allowed calculation of an estimated cumulative BEHI rating for eroding banks rated extreme, very high, high, moderate, low, and very low if human influence was absent. This difference in severity translated to a change in bank retreat rates. The resultant change between the measured and estimated values represents the reduction in sediment load from removing the human influence (i.e. the anthropogenic component). The estimated rates for each eroding bank were then applied to all banks and the anthropogenic component calculated for all assessed reaches. Reaches where bank erosion rates were extrapolated from an assessed reach were assigned the anthropogenic percentage of the assessed reach.